

Curriculum Vitae for Himansu Bhusan Sahoo

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Employment

Post-doctoral Researcher

HEP Neutrino Group, Argonne National Laboratory

Jan 2012–Present

Post-doctoral Research Fellow

Department of Physics, University of Hawaii

Jan 2011–Jan 2012

Graduate Research Assistant

Department of Physics, University of Hawaii

Aug 2004–Dec 2010

Education

Ph.D. in Experimental High Energy Physics, GPA 3.97/4

University of Hawaii at Manoa, USA

2004–2010

Dissertation: Measurements of time-dependent CP violation in B meson decays to $\psi(2S)K_S^0$ and $\phi K_S^0 \gamma$. Supervisor: Professor Thomas E. Browder

Master of Science in Physics, Utkal University, India

2001–2003

First Division (79%) with specialization in Particle Physics

Bachelor of Science in Physics, Utkal University, India

1998–2001

Honors and First Division (72%) in Physics

Research Experience

Post-doctoral Researcher

HEP Neutrino Group, Argonne National Laboratory

Jan 2012–Present

I am now working in NO ν A collaboration, a long-baseline accelerator neutrino experiment, designed to study the oscillation of muon neutrinos to electron neutrinos. My main contribution is the analysis in ν_e appearance group, where I am developing particle identification algorithms for e/π discrimination in NO ν A detectors.

I have also worked for a detector R&D project in exploring various wireless based technology for transmission of data and power to large instrumentation systems. A new prototype wireless data acquisition system has been developed with the intended application to read-out detectors with photomultiplier tube (PMT), that is powered wirelessly and ultimately transfers data wirelessly. I have successfully tested new technologies; radio frequency and optical transmission for wireless power transmission. I was responsible for data readout system; wrote software package to receive in real time the incoming data from front-end electronics and analyze them to test the data acquisition capability. During this project, I gained experience in operation of microwave antennas, dealing with complications arising from high-intensity optical source (LED, Laser) and getting necessary safety approvals for an experiment, testing of photovoltaic panel, PMT and use of radioactive sources. This work is currently in preparation for journal publication.

Post-doctoral Research Fellow
Department of Physics, University of Hawaii

Jan 2011–Jan 2012

During my PostDoc at University of Hawaii, I have worked on the following physics analyses using the full data sample (772×10^6 $B\bar{B}$ pairs) recorded by the Belle detector.

- $B^0 \rightarrow (c\bar{c})K^0$

I was a part of the Indirect CP Violation (ICPV) analysis group in an extensive effort to measure the CP violation (matter-antimatter asymmetries) in all the golden charmonium modes using Belle’s full recorded data sample. I have successfully extended my Ph.D. analysis on $B^0 \rightarrow \psi' K_S^0$ to analyze the full data sample. The results of this channel along with other vector charmonium modes ($B^0 \rightarrow J/\psi K^0$ and $B^0 \rightarrow \chi_{c1} K_S^0$) are used to probe new physics scenarios that predict small differences in the $\sin 2\phi_1$ (also known as $\sin 2\beta$) values. This is world’s most precise measurement of $\sin 2\phi_1$ and is expected to reduce the existing tension in global CKM fit between $\sin 2\phi_1$ and $\mathcal{B}(B \rightarrow \tau\nu)$. The results were published in Phys. Rev. Lett. **108**, 171802 (2012). A Phys. Rev. D paper describing details of the analysis, vertex fit and the parametrization of the resolution function is currently in preparation.

- $B \rightarrow \omega K\gamma$

There is a new radiative $b \rightarrow s$ penguin mode, with similar physics interests as the mode $B \rightarrow \phi K\gamma$. The signal is not observed yet for this channel. I finished a lot of study for this mode on event selection, background suppression, 3D fitting techniques for signal extraction and data sideband study. The work has been presented in several collaboration meetings and an analysis document was written. This analysis is under review by Belle internal referees and will serve as Ph.D. thesis topic of a new graduate student.

I have served as the Belle internal referee for the analysis of $B^0 \rightarrow a_1^\pm(1260)\pi^\mp$ (arXiv:1205.5957) and $B^0 \rightarrow \rho^0\rho^0$ (arXiv:1212.4015) modes. These two papers are currently in preparation for journal publication. I was also the internal referee for the “Charmless B meson decays” chapter of the Physics of B Factories Book.

Graduate Research Assistant
Department of Physics, University of Hawaii

Aug 2004–Dec 2010

During my Ph.D. career, I was a member of the Belle collaboration, a B factory experiment located at the High Energy Accelerator Research Organization (KEK), Tsukuba, Japan. I worked on physics analyses related to the measurements of CP violation in the B meson system using the high statistics data sample collected by the Belle detector from electron-positron collisions.

- $B^0 \rightarrow \psi' K_S^0$

The motivation for this analysis is to precisely measure the time-dependent CP violation, which is sensitive to the angle ϕ_1 (also known as β) of the unitary triangle. This is one of the most precise measurements of $\sin 2\phi_1$, done using a data sample containing 657×10^6 $B\bar{B}$ pairs. The results were published in Phys. Rev. D **77**, 091103 (R) (2008).

- $B \rightarrow \phi K\gamma$

I have analyzed this $b \rightarrow s$ penguin decay using Belle's full recorded data sample. The signal is observed for the first time in the neutral $B^0 \rightarrow \phi K^0 \gamma$ mode. Branching fractions were measured in both charged and neutral modes. The neutral mode is sensitive to new physics from right-handed currents. We performed the first time-dependent CP violation measurements in the neutral mode to probe for this kind of new physics. The signal is found to be concentrated in the $M_{\phi K}$ mass region near threshold. However, due to limited statistics, no clear evidence is found for the existence of a kaonic resonance decaying to ϕK . The results were published in Phys. Rev. D **84**, 071101 (R) (2011).

Hardware Experience

Apart from data analysis, I have also contributed to electronics development in Hawaii group (under the supervision of Prof. Gary Varner) for Belle's Silicon Vertex Detector (SVD), one of the sub-detectors. I designed a new readout board which serves as a bridge between the silicon strip readout chips and a personal computer. During this project, I gained expertise in schematic, layout and routing of printed circuit board (PCB) design, soldering of electronic components to the PCB, writing FPGA firmware program to test functionality of different ICs and finally testing of the board. This board is being used in the cosmic muon beam line experiment that was built in Hawaii.

I have also experience in the GEANT4 simulations; studied the effect of multiple scattering of electrons in layers of pixel prototypes, developed by Hawaii group. This was in an effort to do a beam test for pixel prototypes. I helped in expert level trouble-shooting for the Belle data acquisition system (DAQ) and was responsible for 24 hours on-call service for the operation of SVD during an extended stay at KEK. I also took an active part in the initial step towards the update of Belle resolution function.

I was also responsible for checking the quality of the new data taken by Belle detector as well as the data processed with new tracking algorithm using the decay channels I have analysed.

Summer Research Programme, Institute of Mathematical Sciences, Chennai, India

May 15–June 30, 2002

During my masters program, I was selected along with ten students for a summer students research programme in theoretical physics at Institute of Mathematical Sciences (IMSC), Chennai, India for a period of six weeks. The main focus of the research (under guidance of Prof. Indumathi) was Neutrino Physics, especially on the solar neutrino problem and neutrino oscillation. The work was funded by the Department of Atomic Energy, Government of India.

Computer Literacy

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- **Operating Systems:** Proficiency in MacOS, UNIX, Linux and Windows.
 - **Programming Languages:** Expert in C, C++, L^AT_EX, HTML, Shell scripting languages (bash, tcsh). Knowledge of FORTRAN, Matlab, Mathematica.
 - **HEP Softwares:** Detailed knowledge of PAW, Mn.Fit, ROOT, RooFit.
 - **Simulations:** Expertise in Geant4 simulations of complex detector geometry and the underlying physical processes involved in particle interactions. Knowledge of Evtgen, Pythia. Used the GLOBES neutrino long baseline simulation package to evaluate the detector sensitivity to θ_{13} and CP violation.

Laboratory Experience

- Knowledge of schematic, layout and routing of PCB design using Mentor Graphics PADS software.
- Expertise in soldering of circuit components to a PCB.
- Experience with FPGA Firmware programming using Xilinx software and VHDL language.
- Computing cluster administration and management.

Technical Notes

I have written the following documents describing details of the research work that I have done. The analysis notes are reviewed by Belle internal referees.

- Wireless project :

Wireless data and power transfer techniques for large instrumentation systems.

Standard Operating Procedures for Laser Controlled Area.

- Belle analysis documents :

BN1199 : Branching fraction and time-dependent CP violation in $B \rightarrow \omega K \gamma$ decays.

BN1175 : Time-dependent CP violation in $B^0 \rightarrow \psi(2S)K_S^0$ and $B^0 \rightarrow \chi_{c1}K_S^0$ decays.

BN1107 : Branching fraction and time-dependent CP violation in $B \rightarrow \phi K \gamma$ decays.

BN993 : Time-dependent CP violation in $B^0 \rightarrow \psi(2S)K_S^0$ decays.

Fellowships and Achievements

- **Kotaro Kodama Scholarship** Fall 2009 & Spring 2010
- **Arts & Sciences Student Research Award** Spring 2009
- **Travel Grants Award** Fall 2006

Supported by the Graduate Student Organization (GSO) to attend the 17th DAE-BRNS High Energy Physics Symposium in India.

- **Junior Research Fellowship (JRF)** Dec 2003–July 2004

Qualified twice for the JRF and Eligibility for lectureship through a prestigious examination conducted by Council of Scientific and Industrial Research (CSIR), India, a premier national R&D organization. One semester pre-doctoral study at Indian Institute of Technology (IIT), Kanpur (Spring 2004) was supported by this fellowship.

- **Graduate Aptitude Test in Engineering (GATE)** 2003

Qualified in 2003 GATE examination conducted jointly by the seven IITs in India.

- Qualified in Joint Entrance Screening Test (JEST), India 2003
- **Bachelor of Science with Honors** 2001

Professional Activities

- Member of Division of Particles and Fields, American Physical Society (2005–Present).
- Invited to participate in Student Affiliate's Education Program in East West Center (EWC) (August 10, 2009–December 20, 2010).
- Scientific Secretary, Super B Factory Workshop 2005, Honolulu, Hawaii.
- Member of Student's Council group, Physics department, Utkal University.

Personal Skills

- **Teaching:** Helping undergraduate students with Physics problem solving and giving advice in their project topics.
- **Language:** Proficiency in English and Indian languages Hindi, Oriya. Comfortable with the

basic Japanese language.

- Exposure to international travel for research and conference purposes.

Conferences and Presentations

- The 2012 IEEE Nuclear Science Symposium and Medical Imaging Conference, Anaheim, California, October 29-November 3, 2012, contributed talk on wireless detector R&D.
- **Wireless Power and Data Acquisition System for Large Detectors**, Oral presentation at the 5th Annual Postdoctoral Research Symposium, Argonne National Lab, Illinois, USA, September 20, 2012, Poster presentation at DOE visit, Argonne National Lab.
- Participated in the 4th International Neutrino Summer School (INSS 2012), Virginia Tech, Blacksburg, Virginia, USA, July 10-21, 2012.
- **Exploring Matter-Antimatter Asymmetries in Radiative Penguin Decays at Belle**, invited seminar at Fermilab, Argonne, Brookhaven Lab, October 2011.
- **Measurements of CP Violation in B decays at Belle**, invited review talk at 2011 Meeting of the Division of Particles and Fields of the American Physical Society (DPF 2011), Brown University, Providence, Rhode Island, USA, August 09-11, 2011.
- **Measurements of the CKM angle ϕ_1/β at the B factories**, invited review talk at Flavor Physics and CP Violation 2011 (FPCP 2011), Kibbutz Maale Hachamisha, Israel, May 23-27, 2011.
- Synergy between High Energy and High Luminosity Frontiers (SEL 2011), TIFR, Mumbai, India, January 10-12, 2011.
- **Observation of $B \rightarrow \phi K \gamma$ and Measurements of time-dependent CP violation**, talk given at the 35th International Conference on High Energy Physics (ICHEP 2010), Paris, France, July 22-28, 2010.
- **Radiative B Meson Decays at Belle**, invited review talk at the 2009 Meeting of the Division of Particles and Fields of the American Physical Society (DPF 2009), Wayne State University, Detroit, Michigan, USA, July 26-31, 2009.
- The 17th DAE-BRNS High Energy Physics Symposium, IIT, Kharagpur, India, December 11-15, 2006.
- **B Factories and New Measurements (BNM 2006)**, KEK, Tsukuba, Ibaraki, Japan, September 13-14, 2006.
- Super **B** Factory Workshop 2005, Honolulu, Hawaii, USA, April 20-22, 2005.

List of Publications

Journal Publications

1. H. Sahoo, Z. Djurcic *et al.* (Argonne National Laboratory) **A Wireless Power and Data Acquisition System for Large Detectors** (to be submitted for journal publication)
2. I. Adachi *et al.* (Belle Collaboration), Phys. Rev. Lett. **108**, 171802 (2012), arXiv:1201.4643 (20 INSPIRE citations)
Precise Measurement of the CP Violation Parameter $\sin 2\phi_1$ in $B^0 \rightarrow c\bar{c}K^0$ Decays
3. H. Sahoo, T. E. Browder *et al.* (Belle Collaboration), Phys. Rev. D **84**, 071101 (R) (2011), arXiv:1104.5590 (3 INSPIRE citations)
First Observation of Radiative $B^0 \rightarrow \phi K^0 \gamma$ Decays and Measurements of Their Time-Dependent CP Violation
4. H. Sahoo, T. E. Browder, K. Trabelsi *et al.* (Belle Collaboration), Phys. Rev. D **77**, 091103 (R) (2008), arXiv:0708.2604 (26 INSPIRE citations)
Measurements of time-dependent CP violation in $B^0 \rightarrow \psi(2S)K_S^0$ decays

Preprints and Conference Proceedings

1. H. Sahoo (for the Belle Collaboration), arXiv:1109.4780
Measurements of CP Violation in B Meson decays at Belle, published in the proceedings of DPF-2011, Providence, RI, August 2011 (eConf C110809).
2. H. Sahoo (for the Belle and BaBar Collaborations), arXiv:1107.0503
Measurements of the CKM angle $\phi_1(\beta)$ at the B Factories, published in the proceedings of FPCP-2011, Israel, May 2011 (eConf C110523).
3. H. Sahoo, T. E. Browder *et al.* (Belle Collaboration), arXiv:1104.5590
First Observation of Radiative $B^0 \rightarrow \phi K^0 \gamma$ Decays and Measurements of Their Time-Dependent CP Violation (published in Phys. Rev. D.)
4. H. Sahoo (Belle Collaboration) (BELLE-CONF-1032), arXiv:1012.0481
TCPV Measurements in Radiative $B^0 \rightarrow \phi K^0 \gamma$ Decays, published in the proceedings of ICHEP-2010, Paris, France, July 2010 (PoS(ICHEP 2010)262).
5. H. Sahoo *et al.* (Belle Collaboration) (BELLE-CONF-0921), arXiv:0911.1779
Observation of radiative $B^0 \rightarrow \phi K^0 \gamma$ decays, presented at DPF09, Detroit, USA, July 2009. This conference paper describes details of the branching fraction measurements.
6. H. Sahoo (Belle Collaboration), arXiv:0910.0124
Exclusive Radiative B meson decays at Belle, published in the proceedings of DPF-2009, Detroit, MI, July 2009 (eConf C090726).
7. H. Sahoo *et al.* (Belle Collaboration) (BELLE-CONF-0770), arXiv:0708.2604
Measurements of time-dependent CP violation in $B^0 \rightarrow \psi(2S)K_S^0$ decays, presented at the 2007 Lepton-Photon Symposium, Daegu, Korea, August 2007. (published in Phys. Rev. D.)

Co-author Publications

As I worked in a large collaboration of physicists (nearly 400), I am a co-author of more than 200 publications (for a complete and up to date list please check the INSPIRE webpage). I have significant contributions in all of these in terms of group discussions, writing software for analysis, serving as referee for journal papers, monitoring the online data taking (experimental shifts), monitoring the SVD performance as well as in detector construction. However, I also worked in sub-groups (of nearly 20 people) such as SVD detector group, Charmonium, $b \rightarrow s$ and ICPV analysis groups. Below are the selected publications from the sub-groups where I have active involvement in the analysis.

- P. Vanhoefer *et al.* (Belle Collaboration), arXiv:1212.4015. **Study of $B^0 \rightarrow \rho^0 \rho^0$ decays, implications for the CKM angle ϕ_2 and search for other four pion final states.** (referee of this paper, will be submitted to Physical Review D.)
- J. Dalseno *et al.* (Belle Collaboration), Phys. Rev. D **86**, 092012 (2012), arXiv:1205.5957. **Measurement of branching fraction and first evidence of CP violation in $B^0 \rightarrow a_1^\pm(1260)\pi^\mp$ decays.** (referee of this paper)
- Y. Arai *et al.*, Nucl. Instrum. Methods Phys. Res, Sect. A **623**, 186 (2010). **Developments of SOI monolithic pixel detectors**, presented at the 1st International Conference on Technology and Instrumentation in Particle Physics (TIPP09), Tsukuba, Japan, March 12-17, 2009.
- J. Li *et al.* (Belle Collaboration), Phys. Rev. Lett. **101**, 251601 (2008). **Measurement of the time-dependent CP asymmetries in $B^0 \rightarrow K_S^0 \rho^0 \gamma$ decays.**
- V. Bhardwaj, R. Kumar, J. B. Singh *et al.* (Belle Collaboration), Phys. Rev. D **78**, 051104 (R) (2008). **Observation of $B^\pm \rightarrow \psi(2S)\pi^\pm$ and search for direct CP -violation.**